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ISO/WD 10303-5b
Product data representation and exchange: Integrated resource: Numerical analysis

ABSTRACT:
This provides an initial draft of a resource to support Numerical Analysis.

KEYWORDS: Numerical Analysis, Idealisation

COMMENTS TO READER:
This document is very much work in progress. It is a revised version of the draft Part 5w issued on 2000/09/29. The formal modeling uses EXPRESS, Amendment 1.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10303–5b was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC4, *Industrial data*.

This International Standard is organized as a series of parts, each published separately. The parts of ISO 10303 fall into one of the following series: description methods, integrated resources, application interpreted constructs, application protocols, abstract test suites, implementation methods, and conformance methods. The series are described in ISO 10301-1.

A complete list of parts of ISO 10303 is available from the Internet:
<http://www.nist.gov/sc4/editing/step/titles/>

This part of ISO 10303 is a member of the integrated resource series.

Annexes A and B are a normative part of this International Standard. Annexes C and D are for information only.

Introduction

ISO 10303 is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a neutral mechanism capable of describing product data throughout the life cycle of a product independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

Major subdivisions of this International Standard are:

— **numerical_analysis_schema**;

— **analysis_definition_relationships_schema**.

The relationships of the schemas in this part of ISO 10303 to other schemas that define the integrated resources of this International Standard are illustrated in Figure 1 using the EXPRESS-G notation. EXPRESS-G is defined in annex D of ISO 10303-11. The schemas identified in the bold boxes are specified in this part of ISO 10303. The **action_schema**, **product_definition_schema** and **support_resource_schema** are specified in part 41 of ISO 10303. The **representation_schema** is specified in part 43 of ISO 10303. The schemas illustrated in Figure 1 are components of the integrated resources.

There are many applications that, in one way or another, generate numerical solutions to engineering and mathematical problems. The applications can range from almost trivial, like solving a linear equation which, if the numbers are simple enough, can be performed mentally, to determining the characteristics of a set of experimental data approximating a normal distribution, which requires at least pencil and paper, to a computational fluid dynamics problem which may require several hours of supercomputer time to resolve.

This part of ISO 10303 provides general application independent means of representing analysis problems and the solutions of such problems.

In this International Standard the same English language words may be used to refer to an object in the real world or to a concept, and as the name of an EXPRESS data type that represents this object or concept. The following typographical convention is used to distinguish between these. If a word or phrase occurs in the same typeface as narrative text, the referent is the object or concept. If the word or phrase occurs in a bold typeface, the referent is the EXPRESS data type. Names of EXPRESS schemas also occur in a bold typeface.

The name of an EXPRESS data type may be used to refer to the data type itself, or to an instance of the data type. The disctinction between these uses is normally clear from the context. If there is a likelihood of ambiguity, the phrase ‘entity data type’ or ‘instance(s) of’ is included in the text.

Quotation marks “ ” are used to denote text that is copied from another document. Inverted commas ‘’ are used to denote particular string values.

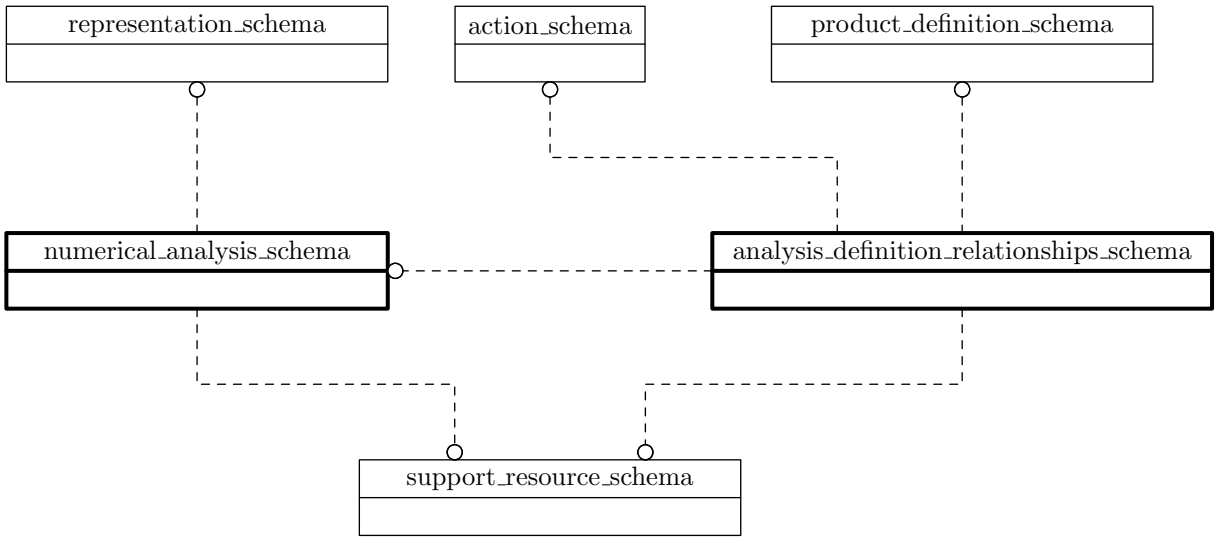

Figure 1 – Schema relationships

Several components of this part of ISO 10303 are available in electronic form. This access is provided through the specification of Universal Resource Locators (URLs) that identify the location of these files on the Internet. If there is difficulty accessing these sites contact the ISO Central Secretariat or the ISO TC184/SC4 Secretariat directly at: `sc4@cme.nist.gov`.

Industrial automation systems and integration — Product data representation and exchange — Part 5b : Integrated resource: Numerical analysis

1 Scope

The following are within the scope of this part of ISO 10303:

— application-independent numerical analysis;

— idealisations of action and product definitions evinced by numerical analyses.

The following are outside the scope of this part of ISO 10303:

— numerical analysis applications;

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this international standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this international standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 10303-1:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 1: Overview and fundamental principles.*

ISO 10303-11:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual.*

ISO 10303-41:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 41: Integrated resource: Fundamentals of product description and support.*

ISO 10303-43:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 43: Integrated resource: Representation structures.*

ISO/IEC 8824-1:1995, *Information technology — Abstract Syntax Notation One (ASN.1): Specification of basic notation.*

3 Terms, definitions, abbreviations, and symbols

3.1 Terms defined in ISO 10303-1

— application protocol (AP)

— generic resource

— integrated resource

3.2 Other definitions

3.2.1
idealisation
a representation of one thing by another thing that in a particular context is both simpler than, and an approximation to, the first thing.

EXAMPLE 1 In the context of a numerical calculation the numbers 3, 22/7, 355/113, and 3.14159265 are all idealisations of the mathematical constant π, in increasing order of reality.

EXAMPLE 2 In the context of a finite element analysis a mesh of elements is an idealisation of the shape of the thing being analysed.

3.3 Abbreviations

URL Universal Resource Locator

4 numerical_analysis_schema

The following EXPRESS declaration begins the **numerical_anlaysis_schema** and identifies the necessary external references.

EXPRESS specification:

```
*)
{iso standard 10303 part (11) version (4)}
SCHEMA numerical_analysis_schema;
  REFERENCE FROM representation_schema
    (representation);
  REFERENCE FROM support_resource_schema
    (label,
     text);
(*
```

NOTE The schemas referenced above can be found in the following parts of ISO 10303:
representation_schema ISO 10303-43
support_resource_schema ISO 10303-41

4.1 Introduction

This schema defines and describes the structures for describing numerical analyses.

4.2 Fundamental concepts and assumptions

Numerical analyses can range from the trivial to highly complex. Nevertheless any numerical analysis can be considered to have four components:

— An analysis space within which a solution to a problem is required. For example, if the problem is to determine whether a diving springboard will break under the weight of a 200kg swimmer, there is no need to consider the overall structure of the building housing the pool, or if the problem is to simulate the flow of a product through a proposed production assembly line there is no need to consider the trucking system delivering component parts to the factory door.

— A set of one or more equations that represent the problem.

— A set of conditions that specify the intial conditions of the problem and/or constraints on the solution to the problem.

— The solution to the problem and auxiliary information relevant to the solution. Examples of potential auxiliary information include error estimates, convergence rates for problems solved iteratively, and so on.

In essence, we can consider the following entity to be representative of a numerical analysis:


```
ENTITY representative_numerical_analysis;
  domain     : domain;
  equations  : SET OF equation;
  conditions : SET OF condition;
  results    : SET OF result;
END_ENTITY;
```

Because of the very broad nature of potential numerical analyses it is not possible to define a detailed model that caters for everything. The model as specified therefore just covers, at an abstract level, the above components. It is expected that other parts of this standard such as an AP, or other standards, that make use of this part of ISO 10303 will specialise the model to meet their own requirements, by subtyping the entities and adding extra attributes and constraints as necessary.

Further, numerical analysis has a life cycle. Although at the end an analysis has all four components at the start of the life cycle none of these may be known, just the fact that there will be an analysis. The order of defining and performing a particular analysis might be:

a) specify the equations;

b) broadly decide on the conditions;

c) decide on the kind of analysis and the domain;

d) specify the conditions in terms of the domain; and

e) perform the analysis and capture the results.

Thus, depending on the analysis and the particular point in its life cycle, practically any combination of the components may be present or absent.

4.3 numerical_analysis_schema entity definitions

4.3.1 numerical_analysis

A numerical analysis may have several components, as outlined in 4.2. These are analysis space (or domain), equations, conditions, and results.

EXPRESS specification:

```
*)
ENTITY numerical_analysis
  SUBTYPE OF (representation);
  descriptions : OPTIONAL LIST OF text;
END_ENTITY;
```



```
SUBTYPE_CONSTRAINT sc1_numerical_analysis FOR numerical_analysis;
  ABSTRACT SUPERTYPE;
END_SUBTYPE_CONSTRAINT;
(*
```

Attribute definitions:

name: (inherited) user-specified instance identifier;

descriptions: is annotation;

4.3.2 analysis_space

The computational space for a numerical analysis.

EXAMPLE Some examples are:

— The mesh for a finite element thermal analysis;

— The multiblock zones for a computational fluid dynamics analysis;

— The node points for a finite difference computation.

EXPRESS specification:

```
*)
ENTITY analysis_space;
  id           : label;
  descriptions : OPTIONAL LIST OF text;
END_ENTITY;

SUBTYPE_CONSTRAINT sc1_analysis_space FOR analysis_space;
  ABSTRACT SUPERTYPE;
END_SUBTYPE_CONSTRAINT;
(*
```

Attribute definitions:

id: user-specified instance identifier;

descriptions: is annotation.

4.3.3 analysis_equation

An equation for solution.

EXAMPLE Some examples are:

— Poisson's equation;

— The diffusion equation;

— Linear constraint equation.

EXPRESS specification:

```
*)
ENTITY analysis_equation;
  id           : label;
  descriptions : OPTIONAL LIST OF text;
END_ENTITY;

SUBTYPE_CONSTRAINT sc1_analysis_equation FOR analysis_equation;
  ABSTRACT SUPERTYPE;
END_SUBTYPE_CONSTRAINT;
(*
```

Attribute definitions:

id: user-specified instance identifier;

descriptions: is annotation.

4.3.4 analysis_state

An **analysis_state** may be an initial state or boundary condition for an analysis or may be the result of an analysis.

NOTE In some cases the result of one analysis may supply the boundary conditions for another analysis.

EXPRESS specification:

```
*)
ENTITY analysis_state;
  id           : label;
  descriptions : OPTIONAL LIST OF text;
END_ENTITY;

SUBTYPE_CONSTRAINT sc1_analysis_state FOR analysis_state;
  ABSTRACT SUPERTYPE;
END_SUBTYPE_CONSTRAINT;
(*
```


Attribute definitions:

id: user-specified instance identifier;

descriptions: is annotation.

4.3.5 analysis_condition

An initial state or boundary condition.

EXAMPLE Some examples are:

— Pressure loading;

— Symmetry;

— Vibration frequency.

EXPRESS specification:

```
*)
ENTITY analysis_condition
  SUBTYPE OF (analysis_state);
END_ENTITY;

SUBTYPE_CONSTRAINT sc1_analysis_condition FOR analysis_condition;
  ABSTRACT SUPERTYPE;
END_SUBTYPE_CONSTRAINT;
(*
```

4.3.6 analysis_result

A result of some computation.

EXAMPLE Some examples are:

— Maximum Mach number;

— Fundamental vibration frequency;

— Stress distribution;

— Product flow rate through a production line;

— Critical path through a PERT chart.

EXPRESS specification:

```
*)
ENTITY analysis_result
  SUBTYPE OF (analysis_state);
END_ENTITY;

SUBTYPE_CONSTRAINT sc1_analysis_result FOR analysis_condition;
  ABSTRACT SUPERTYPE;
END_SUBTYPE_CONSTRAINT;
(*
```

EXPRESS specification:

```
*)
END_SCHEMA; -- end of numerical_analysis_schema
(*
```

5 analysis_definition_relationships_schema

The following EXPRESS declaration begins the **anlaysis_definition_relationships_schema** and identifies the necessary external references.

EXPRESS specification:

```
*)
{iso standard 10303 part (11) version (4)}
SCHEMA analysis_definition_relationships_schema;
  REFERENCE FROM action_schema
    (action);
  REFERENCE FROM numerical_analysis_schema
    (numerical_analysis,
     analysis_state);
  REFERENCE FROM product_definition_schema
    (product_definition);
  REFERENCE FROM support_resource_schema
    (identifier,
     label,
     text);
(*
```

NOTE The schemas referenced above can be found in the following parts of ISO 10303:

action_schema	ISO 10303-41
numerical_analysis_schema	this part of ISO 10303
product_definition_schema	ISO 10303-41
support_resource_schema	ISO 10303-41

5.1 Introduction

This schema specifies relationships between the definitions of:

— a state,

— an activity;

and the idealisations of these definitions for numerical analysis.

5.2 Fundamental concepts and assumptions

An activity or state exists whether or not a numerical analysis is carried out.

NOTE 1 A definition of an activity or state can be recorded using ISO 10303-41.

A numerical analysis is based upon an idealisation of an activity or state. A single activity or state can have many idealisations that are used in or created by many different numerical analyses.

NOTE 2 This schema provides the links between the definitions of concepts contained in ISO 10303-41 and the numerical analysis idealisations of them contained in this part of ISO 10303.

5.3 analysis_definition_relationships_schema entity definitions

5.3.1 analysis_action_idealisation_relationship

An **analysis_action_idealisation_relationship** specifies that a particular **numerical_analysis** is an idealisation of a particular **action**.

EXPRESS specification:

```
*)
ENTITY analysis_action_idealisation_relationship;
  idealised    : action;
  idealising   : numerical_analysis;
  id           : identifier;
  name         : label;
  descriptions : OPTIONAL LIST OF text;
END_ENTITY;
(*
```


Attribute definitions:

idealised: is the **action** that is idealised;

idealising: is the **numerical_analysis** that idealises the **action**;

id: is an identifier for an instance of an **analysis_action_idealisation_relationship**;

name: user-specified human interpretable instance identifier;

descriptions: is annotation.

5.3.2 analysis_state_idealisation_relationship

An **analysis_state_idealisation_relationship** specifies that a particular **analysis_state** is an idealisation of a particular **product_definition**.

EXPRESS specification:

```
*)
ENTITY analysis_state_idealisation_relationship;
  idealised    : product_definition;
  idealising   : analysis_state;
  id           : identifier;
  name         : label;
  descriptions : OPTIONAL LIST OF text;
END_ENTITY;
(*
```

Attribute definitions:

idealised: is the **product_definition** that is idealised;

idealising: is the **analysis_state** that idealises the **product_definition**;

id: is an identifier for an instance of an **analysis_state_idealisation_relationship**;

name: user-specified human interpretable instance identifier;

descriptions: is annotation.

EXPRESS specification:

```
*)
END_SCHEMA; -- end of analysis_definition_relationships_schema
(*
```


Annex A
(normative)
Short names of entities

Table A.1 provides the short names of entities specified in this part of ISO 10303. Requirements on the use of short names are found in the implementation methods included in ISO 10303.

NOTE The short names are available from the Internet — see annex C.

Annex B
(normative)
Information object registration

B.1 Document identification

To provide for unambiguous identification of an information object in an open system, the object identifier

{ iso standard 10303 part(5b) version(-1) }

is assigned to this part of ISO 10303. The meaning of this value is defined in ISO/IEC 8824-1, and is described in ISO 10303-1.

B.2 Schema identification

To provide for unambiguous identification of the **numerical_analysis_schema** in an open information system, the object identifier

{ iso standard 10303 part(5b) version(1) object(1) numerical-analysis-schema(1) }

is assigned to the **numerical_analysis_schema** schema (see 4). The meaning of this value is defined in ISO/IEC 8824-1, and is described in ISO 10303-1.

To provide for unambiguous identification of the **analysis_definition_relationships_schema** in an open information system, the object identifier

{ iso standard 10303 part(5b) version(1) object(1) analysis-definition-relationships-schema(1) }

is assigned to the **analysis_definition_relationships_schema** schema (see 5). The meaning of this value is defined in ISO/IEC 8824-1, and is described in ISO 10303-1.

Annex C
(informative)
EXPRESS listing

This annex references a listing of the EXPRESS entity names and corresponding short names as specified in this part of ISO 10303. It also references a listing of each EXPRESS schema specified in this part of ISO 10303, without comments or other explanatory text. These listings are available in computer-interpretable form and can be found at the following URLs:

Short names: <http://www.mel.nist.gov/div826/subject/apde/snr/>
EXPRESS: <http://www.mel.nist.gov/step/parts/part5b/cd/>

If there is difficulty accessing these sites contact ISO Central Secretariat or contact the ISO TC 184/SC4 Secretariat directly at: sc4sec@cme.nist.gov.

NOTE The information provided in computer-interpretable form at the above URLs is informative. The information that is contained in the body of this part of ISO 10303 is normative.

Annex D
(informative)
EXPRESS-G diagrams

The diagrams in this annex correspond to the EXPRESS schemas specified in this part of ISO 10303. The diagrams use the EXPRESS-G graphical notation for the EXPRESS language. EXPRESS-G is defined in annex D of ISO 10303-11.

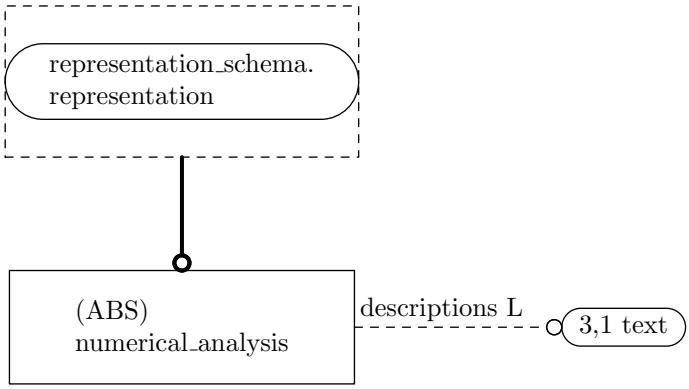

Figure D.1 – Entity level diagram of numerical_analysis_schema schema (page 1 of 3)

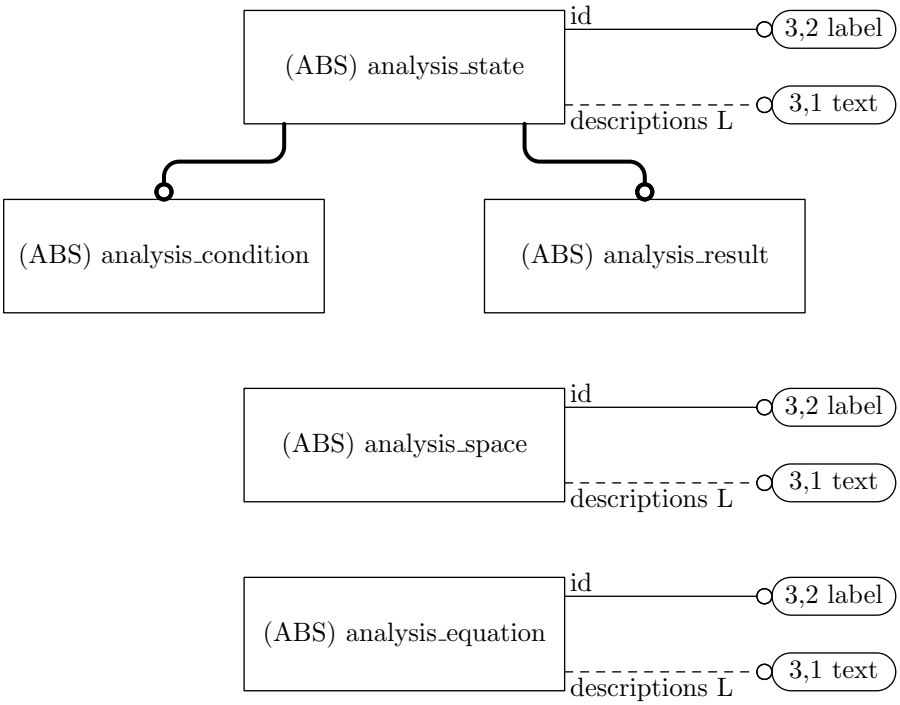

Figure D.2 – Entity level diagram of numerical_analysis_schema schema (page 2 of 3)

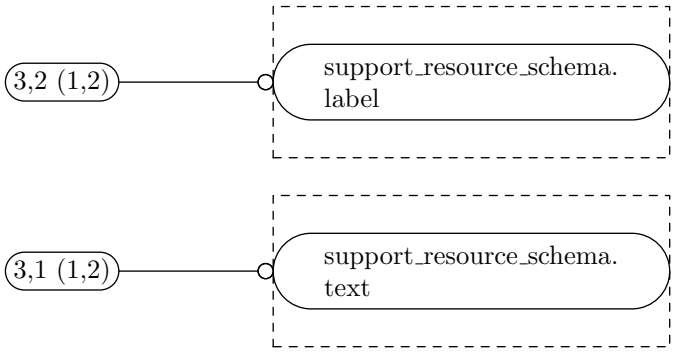

Figure D.3 – Entity level diagram of numerical_analysis_schema schema (page 3 of 3)

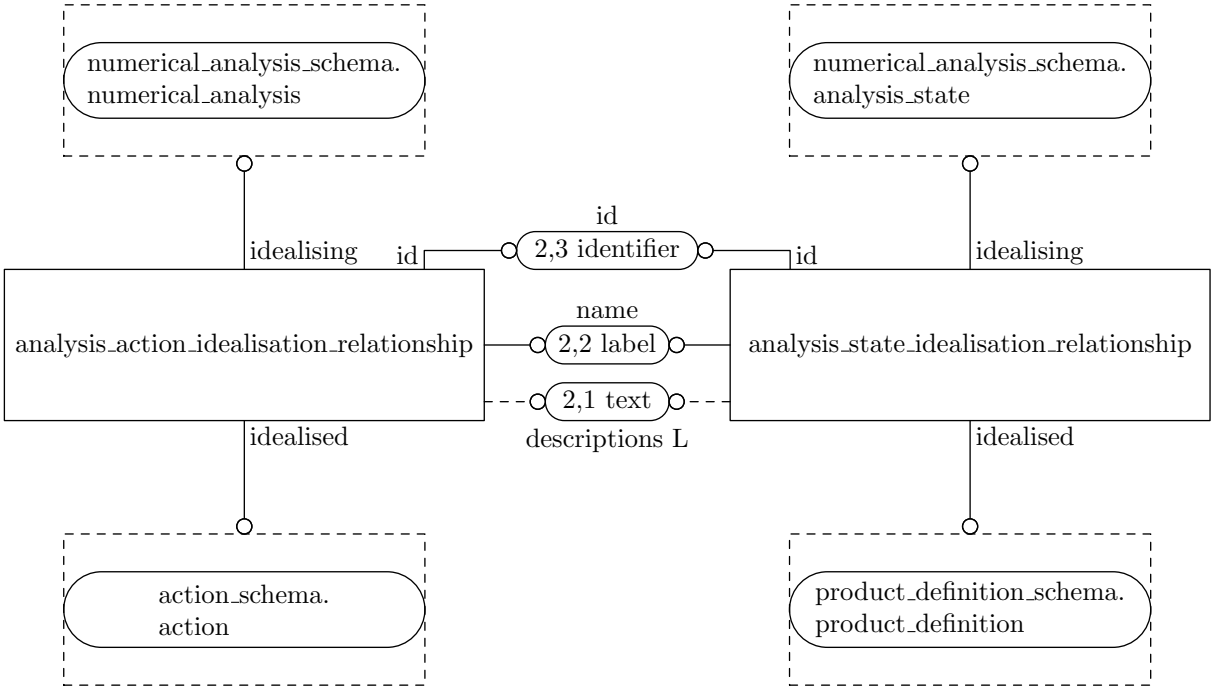

Figure D.4 – Entity level diagram of analysis_definition_relationships_schema schema (page 1 of 2)

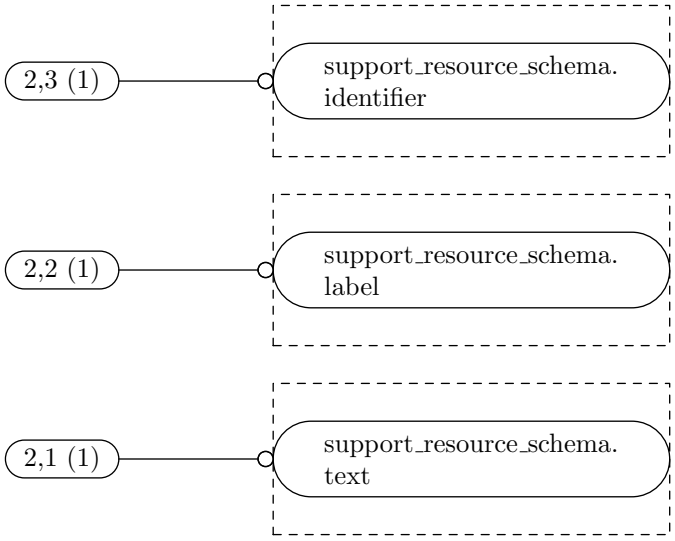

Figure D.5 – Entity level diagram of analysis_definition_relationships_schema schema (page 2 of 2)

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